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Ionospheric heating effects on the polar lower thermospheric wind

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Of vital importance is to qualify significance of the magnetospheric forcing (such as the Joule heating and the ion drag) to the polar lower thermospheric wind dynamics, in order to obtain better understanding of the Magnetosphere-Ionosphere- Thermosphere (MIT) coupling process. Several measurements by Incoherent Scatter (IS) radars and Fabry-Perot Interferometers (FPIs) demonstrated neutral winds with speeds exceeding 300 m/s in the polar lower thermosphere during geomagnetically active intervals. The wind speeds are significantly larger than a typical wind speed (less than 200 m/s). This suggests that the magnetospheric forcing can accelerate the neutral wind. While a number of observations demonstrated relationships between the neutral wind variations and magnetospheric forcing, there are a few studies on examining quantitatively the forcing on the neutral wind based on observational data. A case study determined contributions of the Joule heating and the ion drag on the acceleration of neutral wind at 118 km, and suggested that the Joule heating was a major important factor. At lower heights (below 110 km), however, the heating effects on the neutral wind dynamics are little known. A couple of studies suggest that an anomalous heating on the atmosphere become important for the wind dynamics in the lower heights due to cooling of the heated electrons induced by the Farley-Buneman instability during the strong electric field.

We have investigated such ionospheric heating effects on the wind dynamics at 100-120 km using data obtained with the European Incoherent SCATter (EISCAT) Svalbard Radar (ESR) located in Longyearbyen (78.2N, 16.0E in geographic coordinates, 75.2 in invariant latitude). As a case study, we have determined contributions of the Joule heating, the ion drag, and also the anomalous heating on the neutral wind acceleration at 100–110 km during a strong electric field. The ESR result shows that electron temperatures in the cusp electrojet reach up to about 4000 K. The heat is transferred to the neutral gas by collisions (i.e., cooling of the heated electrons). This anomalous heating effect can be more important at 101–109 km, compared with that at higher altitude. We have found that the anomalous heating effect at 101 km was comparable to the Joule heating effect and occasionally became much more effective. On the other hand the ion drag contribution became less effective. During the strong electric field, at 101 km, the wind speed increase of 60 m/s was found, while the wind speed increase was decreasing with decreasing altitudes. These results suggest that main contributor to the wind acceleration at 101 km would be a total of the anomalous heating and the Joule heating.

Keywords: EISCAT, Polar region, Lower thermosphere, Neutral wind, Ionospheric electric field, Joule heating